EVALUATION OF DIFFERENT MEASUREMENTS FOR EFFECTIVE THERMAL CONDUCTIVITY OF FIBROUS MATERIALS

by

Ming-Wei TIAN [a,b,c]***, Li-Jun QU*** [a,b,c*]***, Shi-Feng ZHU*** [a,b]***, Xiao-Qing GUO*** [a,b,c]***,***
Ya-Ning SUN [a]***, Zhi-You MA*** [a]***, Guang-Ting HAN*** [b]***,***
Kai-Kai SUN [a,b]***, and Xiao-Ning TANG*** [a,b]

[a] College of Textiles, Qingdao University, Qingdao, Shandong, China
[b] Laboratory of New Fiber Materials and Modern Textile, the Growing Base for State Key Laboratory, Qingdao University, Qingdao, Shandong, China
[c] Collaborative Innovation Center for Marine Biomass Fibers, Materials and Textiles of Shandong Province, Qingdao University, Qingdao, Shandong, China

Short paper
DOI: 10.2298/TSCI1405712T

Effective thermal conductivity is generally recognized as the intrinsic factor to reveal the thermal responses of fibrous materials. Here, two typical measurements, the step-wise transient method and the guarded hot plate method, were utilized to identify their feasibility for the effective thermal conductivity of fibrous materials (non-woven fabric and twill fabric) with different stacking layers.

Key words: *effective thermal conductivity, fibrous materials, convection, non-woven, twill*

Introduction

Effective thermal conductivity (*ETC*) is an important parameter to characterize thermophysical property of fibrous materials. The guarded hot plate (GHP) method is recognized as the most accurate steady-state technique for determining the thermal conductivity of fibrous materials [1-3]. However in recent years, some researchers in textile field have attempted to employ the unsteady-state method in measuring fibrous materials, *e. g*., the step-wise transient method [4].

Experimental

Two types of fibrous materials, non-woven and twill, were chosen and their single layer thicknesses were 3.4 mm and 2.9 mm, fabric weights were 4.8 g/m^2 and 143.1 g/m^2, respectively. Both GHP and SWT method were utilized according to refs. [3] and [4]. In GHP method, the default temperature of hot plate was at 30 °C and the cold plate was at 20 °C, so the temperature gradient was ΔT = 10 °C.

Results and discussions

In GHP method, three kinds of non-woven and twill fabric, 3 layers, 5 layers and 10 layers, were stacked and measured. Each experiment was tested five times, and then the average was defined as *ETC*. The results of non-woven and twill fabric via two methods were illustrated in fig. 1.

* Corresponding author; e-mail: lijunqu@126.com

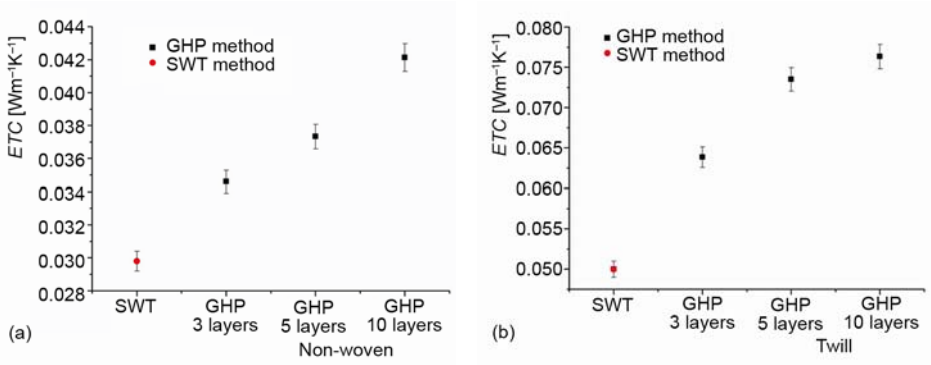

Figure 1. The test result of (a) non-woven and (b) twill fabric

GHP and SWT method have definite discrepancy for fibrous materials. *ETC* obtained by GHP method was always higher than that of SWT. We also found that, in GHP method, *ETC* became bigger with the increasing thickness, resulting from the chaos of internal enhanced heat convection.

Conclusions

The *ETC* of the fibrous materials via SWT was always lower than that of GHP and could be defined as the promising method to determine intrinsic *ETC* of fibrous materials. The heat transfer in GHP not only included heat conduction but also heat convection, caused by the high temperature gradient.

Acknowledgments

This work is supported by Natural Science Foundation of China (No. 51306095 and 51273097), and Taishan scholars construction engineering of Shandong province, program for scientific research innovation team in colleges and universities of Shandong province.

References

[1] Wang, Q. L. *et al.*, Fractional Model for Heat Conduction in Polar Bear Hairs, *Thermal Science*, *16* (2012), 2, pp. 339-342
[2] He, J.-H., A New Fractal Derivation, *Thermal Science*, *15* (2011), Suppl. 1, pp. S145-S147
[3] He, J.-H., *et al.*, Review on Fiber Morphology Obtained by Bubble Electrospinning and Blown Bubble Spinning, *Thermal Science*, *16* (2012), 5, pp. 1263-1279
[4] Tian, M., *et al.*, Measuring the Thermophysical Properties of Porous Fibrous Materials with a New Unsteady-State Method, *Journal of Thermal Analysis and Calorimetry, 107* (2012), 1, pp. 395-405

Paper submitted: March 16, 2014
Paper revised: April 28, 2014
Paper accepted: July 13, 2014